FINAL REPORT

Government of Guam

Installation of GNSS Reference Station Installation at Memorial Hospital for GIS applications

Prepared for:

The Government of Guam

Contract Number: FA4819-15-C-0002

September, 2017

INTRODUCTION AND HISTORY

In September of 2017, Pacific GPS installed a Trimble NetR9 permanent GNSS reference station at the Memorial Hospital located in the city of Tamuning, Guam. The purpose of the reference station is for GIS applications. The permanent installation included a leveling antenna adapter that maintains a consistent point of reference in the event of antenna removal or replacement. A coordinate and ellipsoid height for this point of reference was derived by submitting multiple static data sets observed by the new reference station to the National Geodetic Survey's (NGS) Online Positioning User Service.

To further validate the integrity and usability of the new station, relative static observations were made to local NGS control monuments located within and around the cities of Tamuning and Hagatna in addition to ties to 2 local Continuously Operating Reference Stations (CORS) on the island.

The datum of the coordinate established via OPUS is NAD83(PA11), epoch of 2010.0.

In accordance with the survey regulations in Guam, Pacific GPS contracted Guam Surveyor, LLC to perform local survey observations to both verify the OPUS solution on NAD83 and provide access to the legacy Guam Geodetic Datum of 1993 and the local tidal vertical datum, if necessary.

The Pacific GPS installation was completed between September 26th and September 29th, 2017, inclusive. Technical questions or comments regarding the installation or this report can be directed to:

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Mobile: 808.258.4450
nolan@pacificgps.com

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keith.kirkby@towill.com

PERMANENT GPS BASE STATION

A Trimble Zephyr Geodetic Model 3 antenna was installed in a permanent capacity on top of the north elevator shaft of Memorial Hospital located in Tamuning, Guam.

The GNSS antenna installation hardware consists of a 2-inch diameter stainless steel mast mounted to an adapter that was cemented into 3 drill holes in the concrete roof. A leveling adaptor is fixed to the top of the mast that facilitates a permanent point of reference that remains fixed regardless of antenna removal or model change (see figure 2).

The antenna lead was routed into an existing cable chase located near the southwest corner of the elevator shaft. The cable exits the cable chase into the ceiling of the third floor northward to the server room where the Trimble NetR9 GNSS Receiver was installed. An in-line lightening arrestor was installed within the cable chase shortly before the cable exits into the ceiling.

Reference Point to Bottom of Antenna Offset: 0.0350 meters

The Permanent GNSS Base Station is Labeled 'GUVOV

Figure 1. Permanent GNSS Antenna Installation

The NetR9 GNSS receiver is mounted to the wall in the Hospital server room. The receiver is programmed to record hourly and/or daily GNSS observable files internally.

Figure 2. Antenna Leveling Adapter

BASE STATION OPUS SOLUTIONS

Prior to demobilizing from Guam, 2 independent datasets were submitted to OPUS for processing. The OPUS service processes the dataset against (typically) the closes 3 CORS. In this case the CORS 'GUUG', located at the University, 'GUAM', located at Andersen AFB, and 'CNMR', located in Saipan, were used by OPUS to derive a coordinate and elevation for 'GUGOV'.

The first dataset was acquired on Julian day 270 and consisted of 20 hours of data. The second dataset was acquired on Julian day 271 and consisted of 24 hours of data. The solutions were compared to ensure that there was no significant difference in the coordinate or elevation.

The two datasets were re-submitted to OPUS after the precise ephemeris files became available. The precise ephemerides provide for more accurate relative processing, particularly over long distances.

Table 1 summarizes the OPUS solutions and the comparison between the derived coordinates. The average of the two solution represents the final, OPUS-derived coordinate and ellipsoid height on the ***NAD83(PA11) coordinate datum, epoch of 2010.0.***

OPUS Solutuion Summary
GUGOV Reference Point

Datum: NAD83(MA11); Epoch of 2010.0
Linear Unit: International Meter

Data Set	Latitude	°	'	"	Longitude	°	'	"	Ellipsoid Height
Trim270aA	N	13	30	18.82872	E	144	46	28.89106	119.967
Trim271aA	N	13	30	18.82861	E	144	46	28.89116	119.966
Differences				**Δnorth**				**Δeast**	**Δheight**
				-0.003				0.003	-0.001
Average	N	13	30	18.82867	E	144	46	28.89111	119.967

Table 1. OPUS Solutions

APPENDIX A

OPUS Solutions

FILE: Trim270aA.17o OP1509720084567

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: keith.kirkby@towill.com DATE: November 03, 2017
RINEX FILE: trim270e.17o TIME: 14:44:35 UTC

SOFTWARE: page5 1603.24 master73.pl 160321 START: 2017/09/27 04:04:00
EPHEMERIS: igs19683.eph [precise] STOP: 2017/09/27 23:59:00
NAV FILE: brdc2700.17n OBS USED: 53209 / 54991 : 97%
ANT NAME: TRM115000.00 NONE # FIXED AMB: 179 / 194 : 92%
ARP HEIGHT: 0.035 OVERALL RMS: 0.016(m)

REF FRAME: NAD_83(MA11)(EPOCH:2010.0000) IGS08 (EPOCH:2017.7386)

X:	-5067187.671(m)	0.015(m)	-5067188.507(m)	0.015(m)
Y:	3577860.744(m)	0.018(m)	3577862.501(m)	0.018(m)
Z:	1479839.459(m)	0.008(m)	1479840.862(m)	0.008(m)

LAT:	13 30 18.82872	0.008(m)	13 30 18.86022	0.008(m)
E LON:	144 46 28.89106	0.008(m)	144 46 28.85938	0.008(m)
W LON:	215 13 31.10894	0.008(m)	215 13 31.14062	0.008(m)
EL HGT:	119.967(m)	0.021(m)	121.944(m)	0.021(m)
ORTHO HGT:	65.480(m)	0.036(m)	[H = h-N (N = GEOID12B HGT)]	

	UTM COORDINATES (Zone 55)	STATE PLANE COORDINATES (5400 GU)
Northing (Y) [meters]	1494101.110	200578.777
Easting (X) [meters]	259127.711	102673.179
Convergence [degrees]	-0.51993730	0.00576642
Point Scale	1.00031777	1.00000009
Combined Factor	1.00029890	0.99998122

US NATIONAL GRID DESIGNATOR: 55PBQ5912794101(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF7984	GUUG U OF GUAM CORS ARP	N132559.519	E1444809.793	8527.5

AF9627 GUAM USGS GUAM OBSERV CORS ARP N133521.556 E1445206.127 13761.7
DF7980 CNMR MARIANA ISLAND CORS ARP N151346.882 E1454435.159 217509.4

NEAREST NGS PUBLISHED CONTROL POINT
TW0440 MERCY GG N133019.288 W2151304.581 797.9

FILE: Trim271aA.17o OP1509722031271

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: keith.kirkby@towill.com DATE: November 03, 2017
RINEX FILE: trim2710.17o TIME: 15:16:47 UTC

SOFTWARE: page5 1603.24 master55.pl 160321 START: 2017/09/28 00:00:00
EPHEMERIS: igs19684.eph [precise] STOP: 2017/09/28 23:59:00
NAV FILE: brdc2710.17n OBS USED: 64541 / 67189 : 96%
ANT NAME: TRM115000.00 NONE # FIXED AMB: 238 / 268 : 89%
ARP HEIGHT: 0.035 OVERALL RMS: 0.018(m)

REF FRAME: NAD_83(MA11)(EPOCH:2010.0000) IGS08 (EPOCH:2017.7411)

X:	-5067187.673(m)	0.019(m)	-5067188.509(m)	0.019(m)
Y:	3577860.741(m)	0.019(m)	3577862.498(m)	0.019(m)
Z:	1479839.456(m)	0.006(m)	1479840.859(m)	0.006(m)

LAT:	13 30 18.82861	0.009(m)	13 30 18.86011	0.009(m)
E LON:	144 46 28.89116	0.007(m)	144 46 28.85948	0.007(m)
W LON:	215 13 31.10884	0.007(m)	215 13 31.14052	0.007(m)
EL HGT:	119.966(m)	0.025(m)	121.943(m)	0.025(m)
ORTHO HGT:	65.479(m)	0.043(m) [H = h-N (N = GEOID12B HGT)]		

	UTM COORDINATES (UTM (Zone 55))	STATE PLANE COORDINATES (SPC (5400 GU))
Northing (Y) [meters]	1494101.107	200578.774
Easting (X) [meters]	259127.714	102673.182
Convergence [degrees]	-0.51993729	0.00576642
Point Scale	1.00031777	1.00000009
Combined Factor	1.00029890	0.99998122

US NATIONAL GRID DESIGNATOR: 55PBQ5912794101(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF7984	GUUG U OF GUAM CORS ARP	N132559.519	E1444809.793	8527.5

DF7980 CNMR MARIANA ISLAND CORS ARP N151346.882 E1454435.159 217509.4
AF9627 GUAM USGS GUAM OBSERV CORS ARP N133521.556 E1445206.127 13761.7

NEAREST NGS PUBLISHED CONTROL POINT
TW0440 MERCY GG N133019.288 W2151304.581 797.9

APPENDIX B

NetR9 Configuration Parameters
And
Connection Protocols

The following are the configuration settings and connection protocols that were used during the initial setup of the NetR9 receiver. Note that the configurations can be reset and the information provided below may not be current.

NetR9 GNSS Receiver

IP Address: 192.168.246.2

You can connect to the NetR9 by plugging the Ethernet cable from the NetR9 into your PC, opening a web browser and entering the IP address into the address bar. If you cannot connect, do the following:

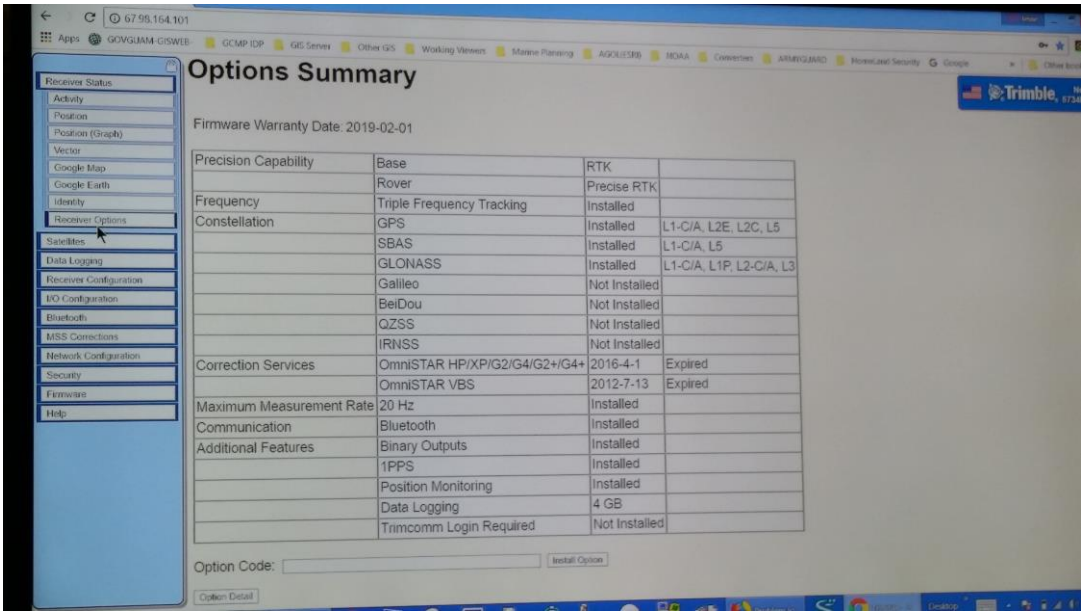
On your PC, go to: Control Panel > Network and Internet > Network Connections and right click on the Local Area Connection icon > Properties. Click on Internet Protocol Version 4 (TCP/IPv4) and click Properties. Select the "Use the following IP address:" radio button and type in 192.168.246.1. Click OK and then open a web browser and try the NetR9 IP address again.

By default, the user name and password are as follows:

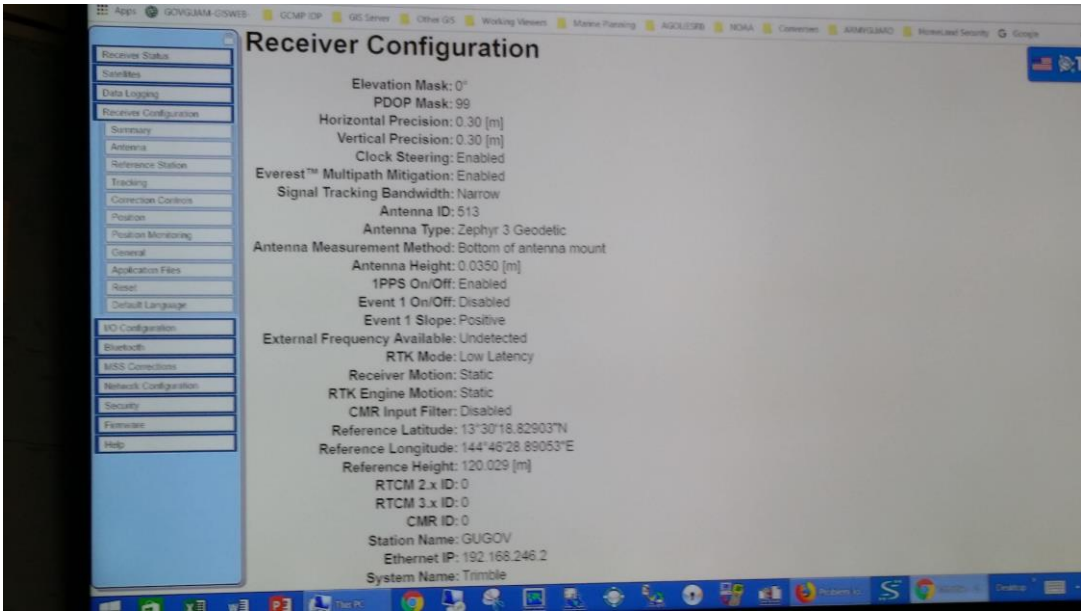
User Name: admin

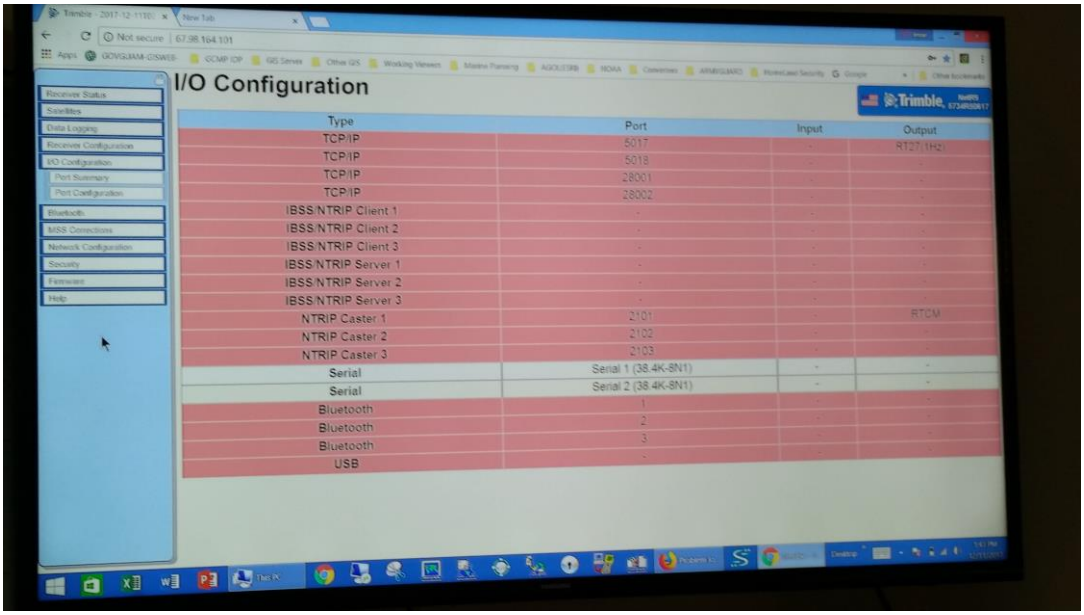
Password: password

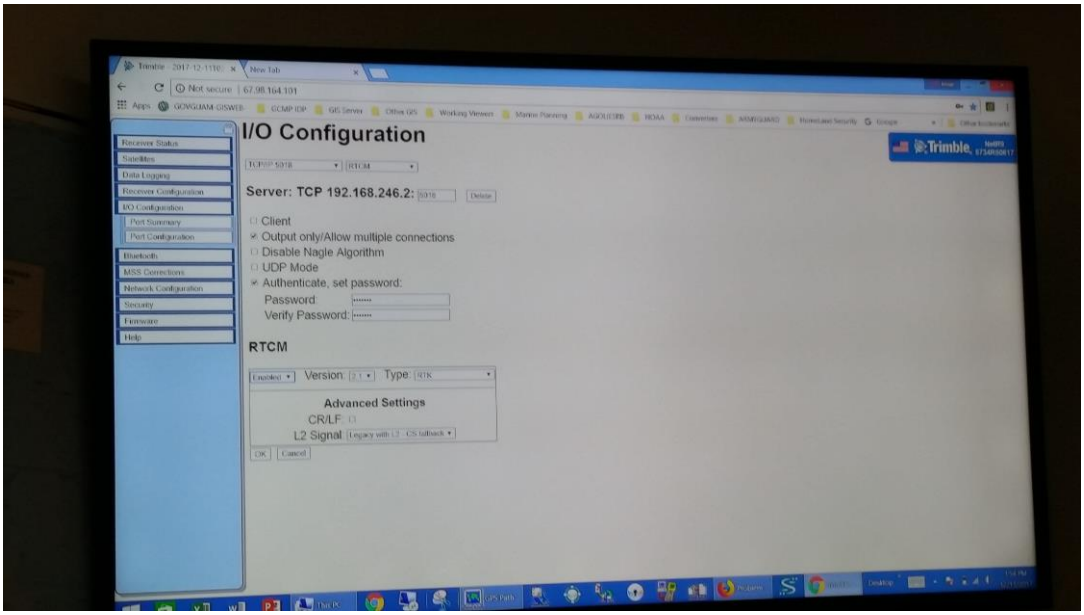
Raw satellite data files are currently being stored on the NetR9 internal memory as well as being actively pushed to an FTP server location with the following server address: 192.168.144.78, server port 21. Raw data files are stored in T02 format and can be converted to RINEX format on-the-fly when downloaded. To access the raw satellite data files, connect to the NetR9 webUI as outlined above. Then navigate to Data Logging > Data Files > Directory: Internal. Then choose the file you want to open and select the raw data files you want to download. Click the Convert button to convert the files to RINEX while downloading. The files are downloaded to the directory on your PC that is specified for internet downloads (often C:\Users\[User Name]\Downloads).

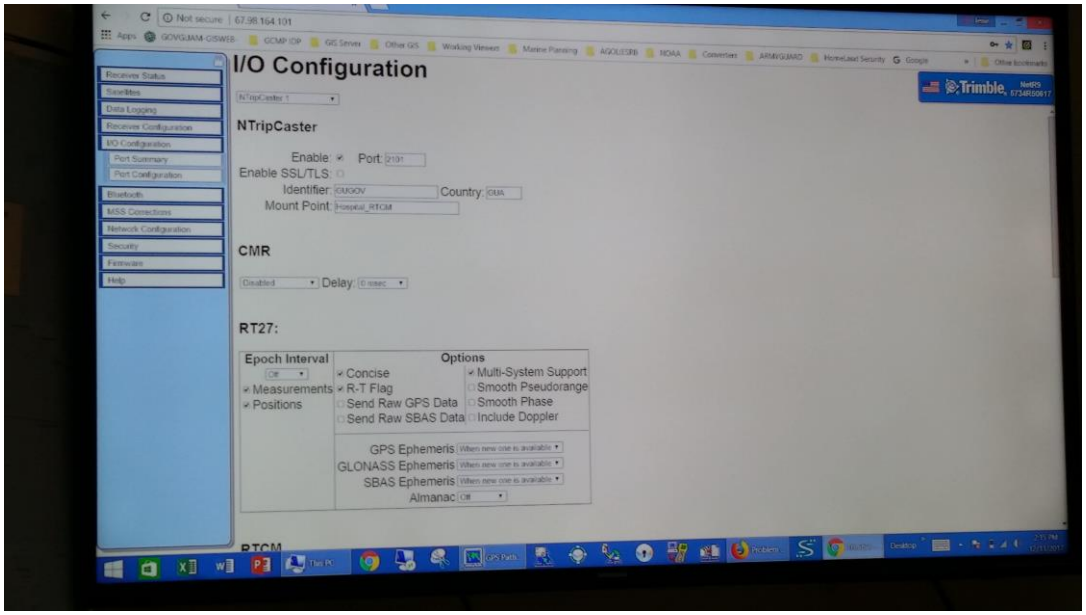


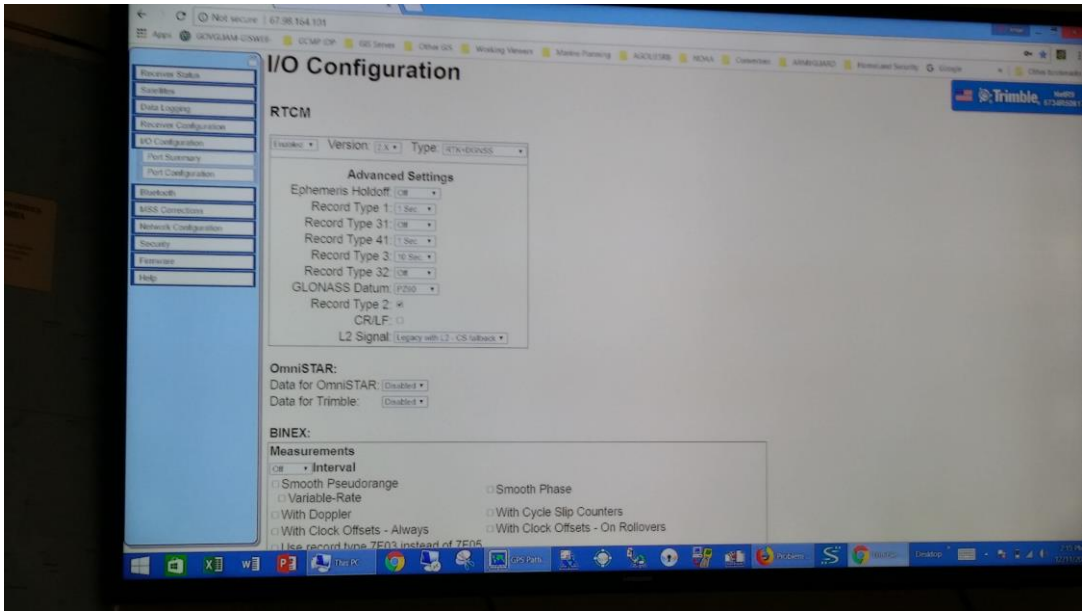
Precision Capability	Base	RTK	
	Rover	Precise RTK	
Frequency	Triple Frequency Tracking	Installed	
Constellation	GPS	Installed	L1-C/A, L2E, L2C, L5
	SBAS	Installed	L1-C/A, L5
	GLONASS	Installed	L1-C/A, L1P, L2-C/A, L3
	Galileo	Not Installed	
	BeiDou	Not Installed	
	QZSS	Not Installed	
	IRNSS	Not Installed	
Correction Services	OmniSTAR HP/XP/G2/G4/G2+/G4+	2016-4-1	Expired
	OmniSTAR VBS	2012-7-13	Expired
Maximum Measurement Rate	20 Hz	Installed	
Communication	Bluetooth	Installed	
Additional Features	Binary Outputs	Installed	
	1PPS	Installed	
	Position Monitoring	Installed	
	Data Logging	4 GB	
	Trimcomm Login Required	Not Installed	

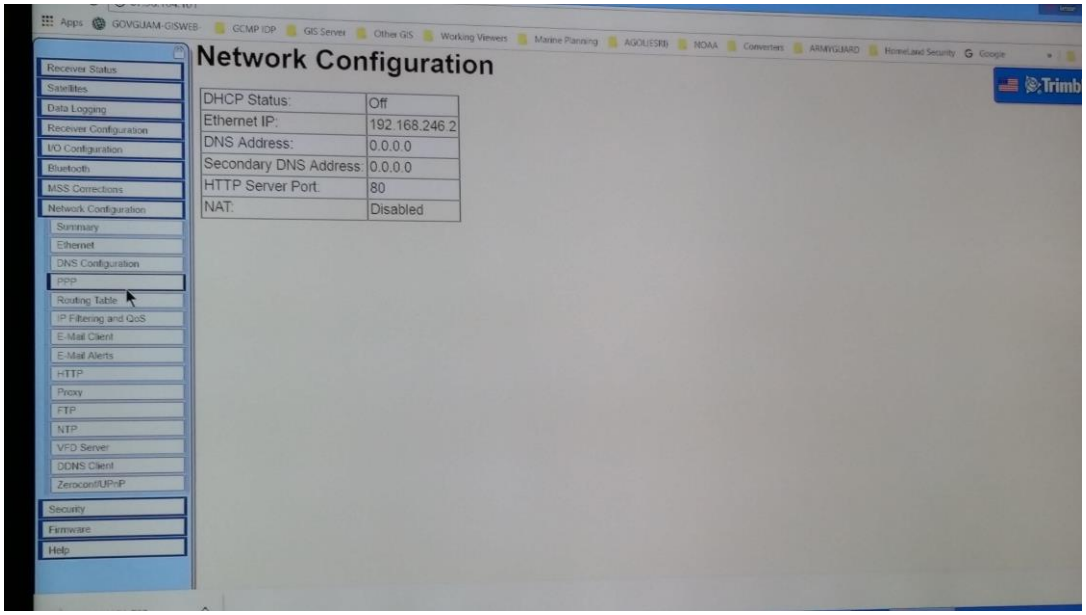


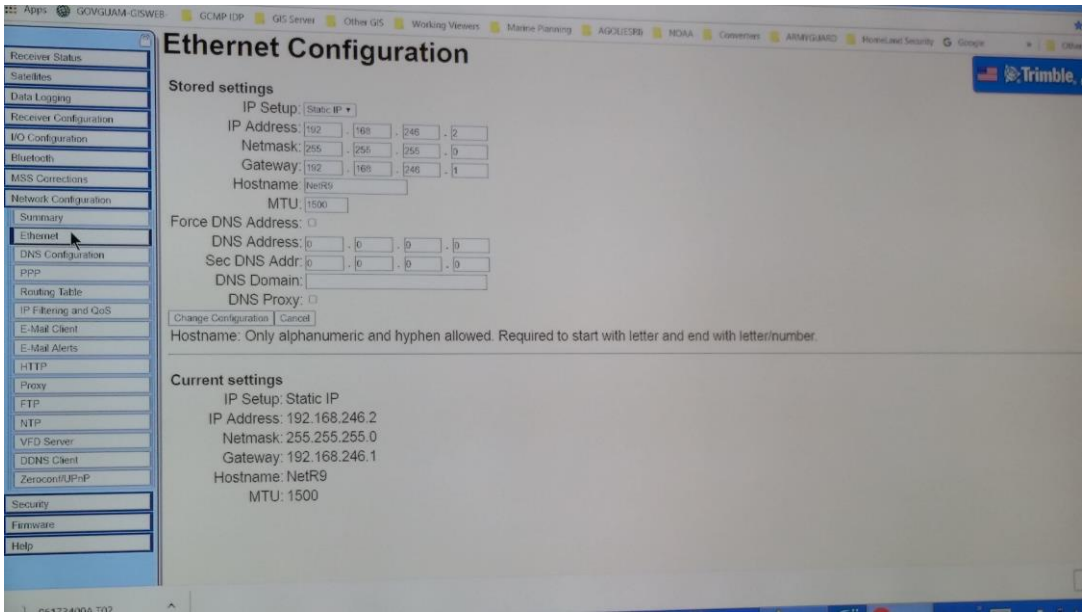

I/O Configuration
Trimble
Receiver Status
Satellites
Data Logging
Receiver Configuration
I/O Configuration
Port Summary
Port Configuration
Bluetooth
MSS Corrections
Network Configuration
Security
Firmware
Help
Type
Port
Input
Output
TCP/IP
5017
RT27 (1Hz)
TCP/IP
5018
TCP/IP
28001
TCP/IP
28002
IBSS/NTRIP Client 1
IBSS/NTRIP Client 2
IBSS/NTRIP Client 3
IBSS/NTRIP Server 1
IBSS/NTRIP Server 2
IBSS/NTRIP Server 3
NTRIP Caster 1
2101
RTCM
NTRIP Caster 2
2102
NTRIP Caster 3
2103
Serial
Serial 1 (38.4K-8N1)
Serial
Serial 2 (38.4K-8N1)
Bluetooth
1
Bluetooth
2
Bluetooth
3
USB

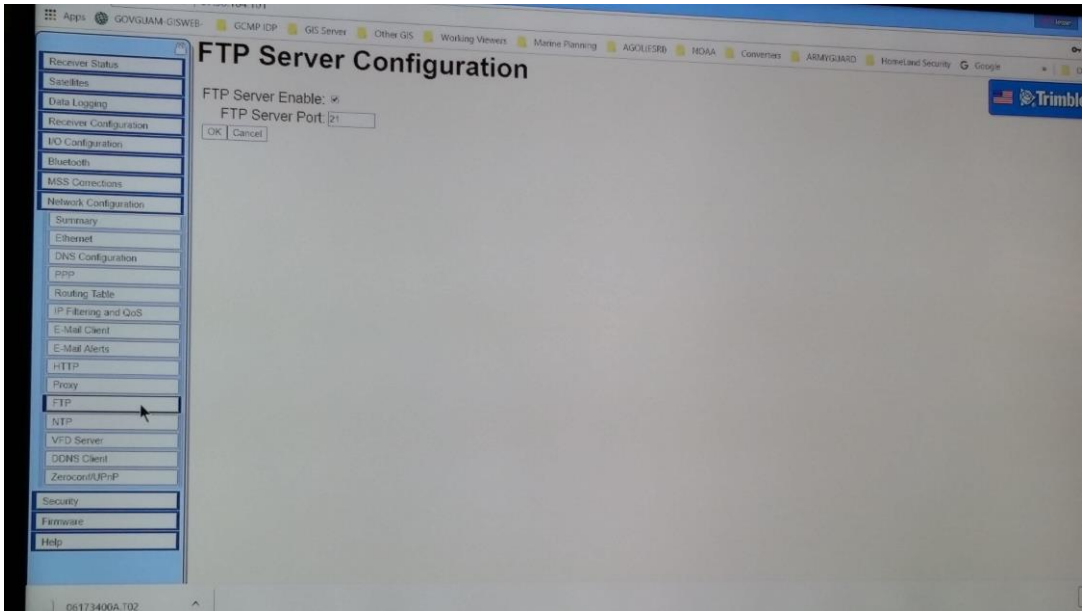

I/O Configuration
Trimble
Server: TCP 192.168.246.2:
Client
Output only/Allow multiple connections
Disable Nagle Algorithm
UDP Mode
Authenticate, set password:
Password:
Verify Password:
RTCM
Version:
Type:
Advanced Settings
CR/LF:
L2 Signal:

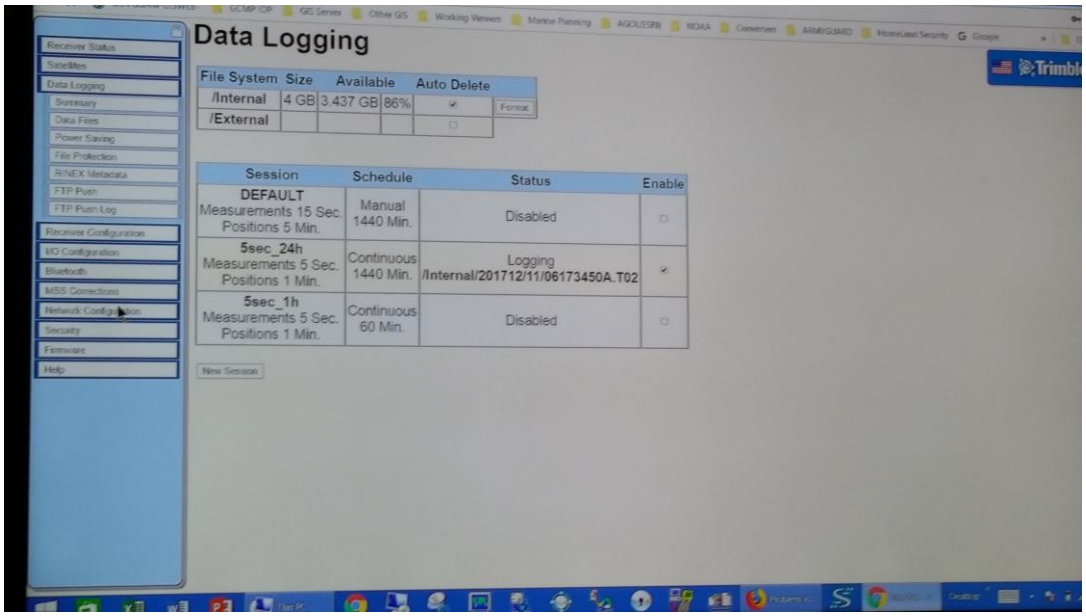

I/O Configuration
NTripCaster
Enable:
Port:
Enable SSL/TLS:
Identifier:
Country:
Mount Point:
CMR
Disabled
Delay:
RT27:
Epoch Interval
Measurements
Positions
Options
Concise
R-T Flag
Send Raw GPS Data
Send Raw SBAS Data
Multi-System Support
Smooth Pseudorange
Smooth Phase
Include Doppler
GPS Ephemeris
GLONASS Ephemeris
SBAS Ephemeris
Almanac
RTCM

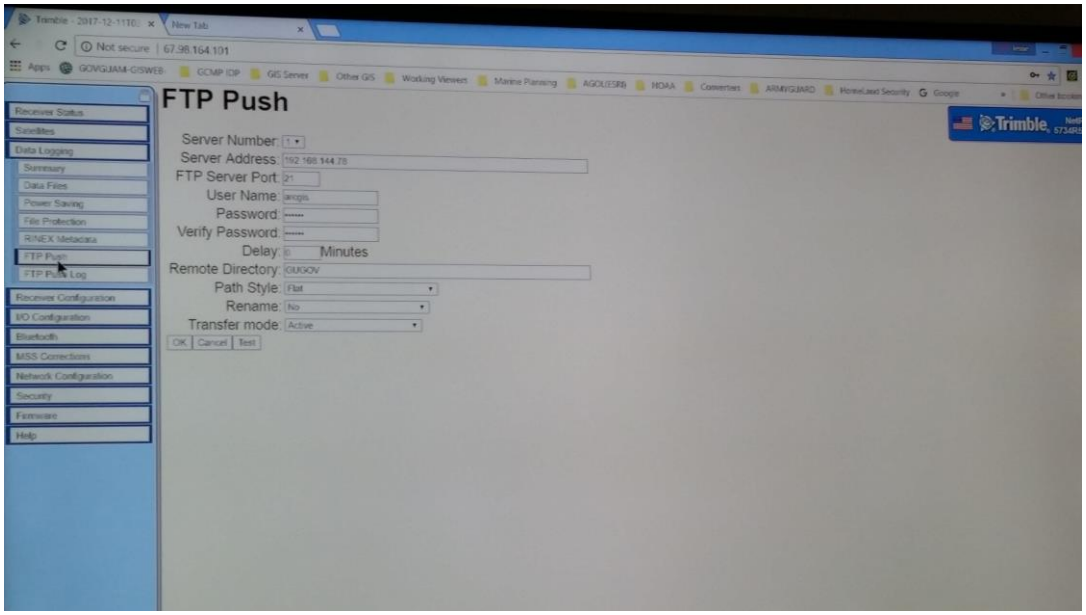

I/O Configuration
RTCM
Version:
Type:
Advanced Settings
Ephemeris Holdoff:
Record Type 1:
Record Type 31:
Record Type 41:
Record Type 3:
Record Type 32:
GLONASS Datum:
Record Type 2:
CR/LF:
L2 Signal:
OmniSTAR:
Data for OmniSTAR:
Data for Trimble:
BINEX:
Measurements
Interval
Smooth Pseudorange
Variable-Rate
With Doppler
With Clock Offsets - Always
Smooth Phase
With Cycle Slip Counters
With Clock Offsets - On Rollovers


Network Configuration
Receiver Status
Satellites
Data Logging
Receiver Configuration
I/O Configuration
Bluetooth
MSS Corrections
Network Configuration
Summary
Ethernet
DNS Configuration
PPP
Routing Table
IP Filtering and QoS
E-Mail Client
E-Mail Alerts
HTTP
Proxy
FTP
NTP
VFD Server
DDNS Client
Zeroconf/UPnP
Security
Firmware
Help
DHCP Status: Off
Ethernet IP: 192.168.246.2
DNS Address: 0.0.0.0
Secondary DNS Address: 0.0.0.0
HTTP Server Port: 80
NAT: Disabled


Ethernet Configuration
Stored settings
IP Setup: Static IP
IP Address: 192 . 168 . 246 . 2
Netmask: 255 . 255 . 255 . 0
Gateway: 192 . 168 . 246 . 1
Hostname: NetR9
MTU: 1500
Force DNS Address:
DNS Address: 0 . 0 . 0 . 0
Sec DNS Addr: 0 . 0 . 0 . 0
DNS Domain:
DNS Proxy:
Change Configuration
Cancel
Hostname: Only alphanumeric and hyphen allowed. Required to start with letter and end with letter/number.
Current settings
IP Setup: Static IP
IP Address: 192.168.246.2
Netmask: 255.255.255.0
Gateway: 192.168.246.1
Hostname: NetR9
MTU: 1500


FTP Server Configuration
FTP Server Enable:
FTP Server Port: 21
OK
Cancel
Receiver Status
Satellites
Data Logging
Receiver Configuration
I/O Configuration
Bluetooth
MSS Corrections
Network Configuration
Summary
Ethernet
DNS Configuration
PPP
Routing Table
IP Filtering and QoS
E-Mail Client
E-Mail Alerts
HTTP
Proxy
FTP
NTP
VFD Server
DDNS Client
Zeroconf/UPnP
Security
Firmware
Help


Data Logging
File System Size Available Auto Delete
/Internal 4 GB 3.437 GB 86%
Format
/External
Session Schedule Status Enable
DEFAULT
Measurements 15 Sec.
Positions 5 Min.
Manual
1440 Min.
Disabled
5sec_24h
Measurements 5 Sec.
Positions 1 Min.
Continuous
1440 Min.
Logging
/Internal/201712/11/06173450A.T02
5sec_1h
Measurements 5 Sec.
Positions 1 Min.
Continuous
60 Min.
Disabled
New Session


FTP Push
Server Number:
Server Address:
FTP Server Port:
User Name:
Password:
Verify Password:
Delay:
Minutes
Remote Directory:
Path Style:
Rename:
Transfer mode:
OK
Cancel
Test
Trimble